

(18)



Europäisches Patentamt

European Patent Office

Office européen des brevets

(11) Publication number:

**0 160 293
B1**

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **28.06.89**

(51) Int. Cl.⁴: **B 23 K 26/08**

(21) Application number: **85105212.6**

(22) Date of filing: **29.04.85**

(54) **Laser welding system and apparatus.**

(30) Priority: **03.05.84 US 606791**

(43) Date of publication of application:
06.11.85 Bulletin 85/45

(45) Publication of the grant of the patent:
28.06.89 Bulletin 89/26

(84) Designated Contracting States:
BE DE FR GB IT NL SE

(58) References cited:
**DE-A-3 141 881
FR-A-2 411 061
JP-A-58 068 492
US-A-4 237 363
US-A-4 364 535**

(73) Proprietor: **Cincinnati Milacron Inc.**
(a Delaware Corporation), 4701 Marburg Avenue
Cincinnati, Ohio 45209 (US)

(72) Inventor: **Bannister, Robert Dean**
6579 Windfield Court
Loveland, Ohio 45140 (US)

(74) Representative: **Lally, William et al**
FORRESTER & BOEHMERT Widenmayerstrasse
4/I
D-8000 München 22 (DE)

EP 0 160 293 B1

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Description

The present invention relates to a laser spot welding apparatus for use with a manipulator mechanism such as an industrial robot.

Conventional electric spot welders are used in conjunction with industrial robots for processing work on automotive assembly lines. Such spot welders are generally connected to the manipulatable end effector of the robot and are movable to perform a variety of welding tasks.

Conventional electric spot welders are constructed as follows: A pair of opposing copper tips are movable between open and closed positions with respect to one another so that they may tightly clamp a workpiece between the tips. The welding guns, as they are referred to, have an electrode force clamping package in the neighbourhood from 600 and 1500 lbs (2668 and 6672 N) to be exerted against the workpiece. High amperage current is then passed through the electrode pair causing resistance welding to occur at the build up of heat at the interface of two layers of weldable material. The electrode and clamping mechanism is fitted with a cooling water line to remove the heat from the welding tool.

Many disadvantages are associated with conventional electric resistance spot welding guns. For example: the high mechanical clamping forces cause deformation of the relatively soft copper electrode over a period of time; similarly, an indentation is caused on the sides of the workpiece during welding; the high temperature of the electrode tips causes a gradual burning and degradation of the electrode tip; the electrode tips must be periodically redressed to present a shiny and properly shaped end to the workpiece; and the electrodes must periodically be replaced.

When conventional electric resistance spot welding guns are employed at stationary work stations, the power supply and related connections do not present a problem. However, when used in conjunction with the movable end of a robot, the difficulty of moving the end package and its associated connections becomes of paramount importance. The conventional spot welding gun requires a transformer to be carried with the robot and heavy copper wires to be connected from the transformer to the welding gun. These wires as well as the water cooling hoses cause additional weight to be borne by the industrial robot. Additionally, the wiring package is usually not very flexible, and thus the robot will be faced with mechanical drag and resistance when performing its programmed moves.

It has been proposed to employ lasers in conjunction with industrial robots to perform a variety of tasks previously done with conventional tools. For example, industrial robots have utilised a laser beam to cut and trim workpieces. Such laser beams may typically emanate from a CO₂ light source, and a problem encountered is that the laser generating unit such as a 1.5 KW

"power laser" to perform work on industrial workpieces may weigh in the order of 350 and 550 lbs (15 g and 250 kg). Therefore, it has been proposed that the light source be located somewhat remote from the robot unit and that the light beam be directed through an articulatable conduit having a flexible arm structure with totally reflecting mirrors positioned in its articulation joints, such as might be used in laser surgery. At the end of the system, the laser beam is focused to a small spot by a focusing lens provided in the end of the light conducting mechanism. The focusing lens unit is typically connected in some fashion to the end effector of a robot, so that the robot may perform its programmed moves and need only be concerned with carrying the output end of the laser conducting mechanism.

It has been proposed that a laser beam source be used for welding operations, see for example Japanese Publication 58-68492. In consideration of a spot welding operation, two layers of a weldable material must be intimately placed in contact with one another and a laser beam directed at at least one surface of the layered assembly. Sufficient heat is generated by a power laser to cause an interface melting of the two materials and a consequent weld formation between the two. It would seemingly be a relatively simple task to therefore perform spot welding operations utilising a laser beam in industrial application by simply focusing the beam at a desired number of spots on material to be welded. However, in practical application, the task of performing production spot welding intervals is a difficult one for the reason that the workpieces generally are not totally flat and therefore, are not in intimate contact with one another. Mechanical misalignments of components to be welded, and slight deformations and tolerance variations may cause the weldable materials to be slightly spaced apart at the weld site.

According to this invention there is provided a laser welding apparatus for use with an industrial robot, comprising:

- (a) a base frame;
- (b) a workpiece support;
- (c) a clamping device carried by the base frame;

(d) means for moving the clamping device to clamp the workpiece against the workpiece support; and

(e) means to direct a laser beam against a workpiece clamped between the support and the clamping device; characterised in that the workpiece support is carried by the base frame and the apparatus comprises means for mounting said base frame on an end effector of the robot, and in that the clamping device comprises a linear piston which is provided with a through-extending axial passageway, means being provided to direct a laser beam along said axis into said passageway through the linear piston onto the workpiece.

In use, the base frame is mounted on the end effector of the robot, conventionally movable through multi-vector spatial orientations, and the means for directing a laser beam into said laser aperture is connected to a remote laser beam generator.

Preferably the linear piston is movable in a fluid cylinder mounted on the base frame.

Conveniently the apparatus comprises a tubular member relatively fixed to the base frame and telescopically fitted with said linear piston.

Advantageously focusing mechanism is provided, which may be carried in unison with said clamping device as said member moves relative to said base frame, but which may be fixed relative to the base frame.

The apparatus preferably comprises a compression member provided by or adjacent to one end of said linear piston, or may comprise, in part, a roller having its rotary axis substantially normal to the axis of movement of said linear piston.

Conveniently the means for directing a laser beam into the laser aperture comprises a jointed-light type conductor system connecting a remote laser beam generator to said laser apparatus.

According to this invention there is also provided a laser welding machine comprising:

(i) an industrial robot having a wrist and wrist end effector movable through multi-vector spatial orientations;

(ii) a workpiece support; and

(iii) a laser welding apparatus comprising

(a) a base frame;

(b) a clamping device and

(c) means for moving the clamping device to clamp a workpiece against the workpiece support;

characterised in that the workpiece support is carried by the base frame and the base frame is mounted on the end effector of the robot, and in that the clamping device comprises a linear piston with a through-extending axial passageway, the machine comprising an articulative light conductor system adapted to be connected at one end to a remote laser beam generator and at the other end to the welding apparatus in a manner whereby a laser beam may be directed during a welding operation from the remote laser beam generator through the axial passageway of the clamping device onto said workpiece.

Preferably, the articulative light conductor system is connected at said other end to a hollow member fixed in relation to the base frame, said hollow member being telescopically mounted relative to said clamping device, to move axially relative thereto during movement of the clamping device into engagement with said workpiece.

There will now be given a detailed description, to be read with reference to the accompanying drawings, of three laser spot welding apparatuses which are the preferred embodiments of this invention, having been selected for the purposes of illustrating the invention by way of example, and which are for use in combination with industrial robots.

In the accompanying drawings:

Figure 1 is a side elevational of the first embodiment seen secured to an industrial robot in the performance of a spot welding operation;

Figure 2 is a schematic representation of the first embodiment, simplified in construction details;

Figure 3 is a side elevation showing an alternate construction of anvil;

Figure 4 is a detailed side elevational view of the first embodiment;

Figure 5 is a bottom plan view of the first embodiment taken in the direction of arrow 5 of Figure 4;

Figure 6 is a right end elevational view of the first embodiment taken in the direction of arrow 6 of Figure 4;

Figure 7 is a left end elevational view of the first embodiment taken in the direction of arrow 7 of Figure 4;

Figure 8 is a view corresponding to Figure 2 of the second embodiment of the invention; and

Figure 9 is a general perspective view of the third embodiment of the invention, showing a robot carried laser generator source.

Referring to Figure 1 of the drawings, there is shown an environmental view of a laser spot welding apparatus 10 for performing work on a typical workpiece, such as the automobile door panel 11 depicted, comprising of layered weldable material. The door panel 11 is carried on an overhead trolley 12 supported by floor stands 13, and the laser spot welder 10 is manipulatable around the workpiece area by an industrial robot 14. The industrial robot 14 pictured is an articulatable jointed arm robot such as that depicted in U.S. Design Patent 269,681, wherein a base 15 is carried on the floor and a shoulder joint 16 is rotatable on the base 15. An upper arm 17 and forearm 18 are movable with respect to the shoulder joint 16. The wrist 19 carried on the forearm is substantially of the same assembly shown in U.S. Patent No. 4,068,536. The wrist 19 has three rolls of movement, and the end effector 20 is affixable to robot tooling. The laser spot welder 10 is mounted to the end effector 20 of the wrist 19. Here it should be noted that other types of manipulators and robots may be employed to carry the laser spot welder 10, and similarly other types of wrists may be employed which may be limited in roll or to bend movements without departing from the spirit of this invention.

A laser beam source (not shown) provides a laser beam which is ducted through a light conducting mechanism 21 having a flexible arm structure comprising of light pipes 22 serially jointed at articulated joints 23. The articulation joints 23 have totally reflecting mirrors positioned therein for properly directing the light beam axially along the light pipes 22. The final articulation 24 in the jointed assembly is attached to the laser spot welder 10 at a laser aperture 25 for admitting the light beam.

Figure 2 shows a schematic representation of the laser spot welder 10 of Figure 1, wherein basic

elements of the assembly are depicted. The base frame 26 consists of a generally plate-like support member attached to the movable and effector 20 of the robot wrist 19, and one end of the frame is provided with an upright plate 27. The plate 27 has an anvil 28 attached thereto which, in the preferred embodiment, comprises a ring for providing an annular clamp area to a pair of weldable workpieces 29, 30. Midspan the structure, the spot welder 10 is provided with a fluid cylinder 31 having its axis aligned with the axis of the anvil 28, i.e. a parallel to the base frame plate 26. The fluid cylinder 31 is fitted with a movable piston 32 and a piston rod 33 extends from both ends of the piston 32. The forward end 33(a) of the piston rod 33 has an anvil compression member 34 which basically consists of an annular ring area matched to the anvil for clamping the pair of weldable workpieces 29, 30. The double-ended piston rod 33 therefore serves as a linear way system to guide the anvil compression member 34. The piston rod 33 has a laser-conducting bore 35 machined coaxially with the rod 33.

The forward end 33(a) of the rod 33 is also fitted with a laser focusing mechanism 36, which may comprise a variety of focusing lenses and the like adapted to be located within the rod 33 as shown in Figure 4. The purpose of the focusing mechanism, 36 is to concentrate and focus the laser beam to a target spot 37 proximal the anvil compression member 34 so that when the anvil 28 and anvil compression member 34 are clamped against the workpieces 29, 30 the focus spot 37 will cause localised heating and welding of the workpieces 29, 30. Here it should be noted that the focusing mechanism is not considered an obstruction, even though it may be of solid construction. The lens system employed in the unit is substantially invisible to the laser beam. The incoming, unfocused beam of a power laser may be approximately 5/8" in diameter. The focus mechanism 36 increases the density of beam energy, in watts per square inch. By mounting the focusing lens 36(b) in close proximity to the end of the compression member 34, the beam will not tend to diverge as much as a beam focused at a point more remotely located from the weld zone (for example, at or near the aperture 25), thus tending to ensure the concentration of energy at the work site.

The opposite end 33(b) of the piston rod 33 is open and unobstructed, and a laser aperture tube 38 is telescopically fitted within the piston rod 33. The tube 38 is clamped to an upright clamp block 39 which is affixed to the base frame plate, 26 and aligned so that its bore 40 is coaxial with the bore 35 of the piston rod 33. The laser aperture tube 38 is adjustably mounted and clamped by a plurality of clamp screws 41 in the upright block 39. The aperture tube 38 has a flange 42 at its outermost end and bolt holes 43 are provided therethrough for affixing the final articulation 24 of a laser beam light conducting mechanism 21. The beam is reflected from a mirror in the articulation 24 through an inlet or laser aperture 25 and ducted

through the piston rod 33 and focus mechanism 36 for joining workpieces 29, 30 to be welded.

It has been determined that slight bends and misalignments of the workpieces 29, 30 to be joined may be overcome by a very slight clamping force, i.e. in the nature of several pounds. Since the clamping force is not necessary to effect the weld, as in conventional electric resistance spot welder guns, tonnage is not required to place the workpieces 29, 30 in intimate contact with one another. Also, in the preferred embodiment, the annular anvil ring concept is employed for introducing clamping pressure on an annular area so that deformation of the workpiece external surfaces will not occur in the softened weld zone. However, it may be appreciated that the anvil 28 and cooperating anvil structure may be any of several possible configurations including that having a solid anvil surface.

While the apparatus has been described so far in connection with a fixed workpiece and spot welding operation, it may be appreciated that the workpieces may, in some instances, necessarily be moved for adjustment purposes or for extending the length of a weld. In such instances, the clamp force and friction coefficient of the anvil 28 and anvil compression member 34 becomes a consideration. An alternate embodiment of the invention is shown schematically in Figure 3, wherein an antifriction roller mechanism 44 is used to hold the workpieces 29, 30 together. The anvil unit thus comprises a fixed block 45, having a pair of oppositely-extending antifriction rollers 46, such as cam followers, which are rotatable with respect to the fixed block 46 around axes transverse to the base plate 26. A matching pair of rollers 47 are mounted to the piston rod 33 by the threaded studs 48 shown. In such fashion the laser conductor bore 35 remains unobstructed, so the laser beam may reach the target. The roller circumference extends to a point beyond the end of the piston rod 33, so no rubbing will take place as the workpiece 29, 30 are moved bidirectionally (in the plane of the paper, as viewed by the reader). The clamping force is impressed by the piston 32, so the oppositely reacting rollers will cause the workpiece surfaces to lay on one another intimately for a spot welding operation or for a continuous welding operation.

In many cases, the workpiece 20 may function as its own "anvil", due to being formed into a stiff configuration, for example, a box or channel section. In such cases, the plate 27 and anvil 28 may be omitted and the workpiece 29(a) will alone provide a sufficient reaction force for the compression member 34, as shown in Figure 2(a). Similarly, the assembly shown in Figure 3 may be modified to the structure in Figure 3(a) where the workpiece 29(a) is of sufficient stiffness.

The actual structure of the laser spot welder 10 is depicted in Figure 4, wherein the base frame 26 comprises front and rear fabricated members 49, 50 bolted together. The rear member 50 comprises, in part, a horizontal plate 51 having vertical stiffener gussets 52 welded thereto and to a

forward, downwardly-extending vertical end plate 53. The gussets have lightening holes 54 machined throughout to reduce the weight of the structure. The front member 49 has a matching vertical end plate 55 and a main horizontal plate 56. The interface 57 of the vertical plates 53, 55 is fitted with screws 58 and nuts 59 to form a secure assembly. The outermost end of the front member horizontal plate 56 has an upwardly-extending vertical plate 27 welded thereto for supporting an anvil 28. A stiffener gusset 60 is welded to the horizontal and vertical plates 27, 56 and has a series of lightening holes 61 therein. The anvil 28 is a cylindrical piece having its axis horizontally disposed and having counterbore 62 in its front face so as to provide an annular compression area 63. The rear face of the anvil 28 is mounted to the vertical plate 27 by screws 64.

Midspan of the structure, a cylinder support bracket 65 is bolted to the rear member 50 of the base frame 26. The bracket 65 comprises a weldment having burned out portions 66 to lighten to structure. The top surface of the bracket 65 is fitted with a fluid cylinder 31 having front and rear fluid ports 67, 68 moving a companion piston 32 bidirectionally and parallel to the base frame plate 51. Extending from the piston 32 are front and rear extending portions 33(a) and 33(b), of a piston rod 33 and a bore 35 is provided throughout the piston rod length. The bore 35 serves as a laser beam conductor. The outboard extremities 69, 70 of the piston rod 33 are provided with external threads. The forward end 69 of the piston rod 33 has a collar 71 threadably received thereon with a locknut 72 for axially positioning the collar 71. The collar 71 is threaded throughout its length and the laser focus mechanism 36 is threadably received therewith to form a coupling with the piston rod 33. The laser beam focus mechanism 36 basically consists of a hollow housing 36(a) supporting an internally-mounted lens 36(b) for converging the beam. The lens 36(b) may comprise a plurality of stacked cooperating lenses. The converging beam exits the end of the housing 36(a) through an orifice 36(c).

The rear portion 73 of the exterior of the collar 71 is threaded and the central exterior portion of the collar has a circular groove 74. A tubular anvil compression member 34 is slidably received on the forward end of the collar 71 and is positioned against a lock nut 75 threadably received on the collar 71. When the axial position of the tubular member 34 is correct, the member 34 is held with the collar 71 by a set screw 76 extending through the member 34 and into the circular groove 74. The compression member 34 is cylindrical throughout the majority of its length and of substantially constant wall thickness, extending to a converging tapered end portion 77 which terminates at an annular facial ring. The annular ring 78 is matched to the anvil 28 for holding a pair of workpieces together. As shown in the drawing, the convergent point 37 of the laser beam is focused just outside the face of the anvil compression member 34, to cause localised heat-

ing at the interface of a pair of workpieces. The convergent point 37 is adjustable for workpiece thicknesses. The rearwardly extending piston rod portion 33(b) has a tubular member 79 threadably received therewith, and extending rearwardly to an exterior flange portion 80. The majority of the length of the tubular member 79 is smoothly machined.

The rearmost portion of the base frame plate 51 has a rear support bracket 81 bolted therewith, and the rear support bracket comprises a fabrication similar to the cylinder support bracket 65, i.e., a weldment created by plates and gussets, and burned out portions 82 are provided to relieve the weight. The top surface of the rear bracket 81 supports a clamp block 39 affixed by screws 83 and nuts 84, and a bore 40 is provided through the clamp block 39 coaxial with the piston rod 33. The top section of the clamp block 39 has a saw slot 85 cut through to the bore 40 (see Figure 6), and transverse clamp screws 41 are provided so that the block 39 may clamp securely on a laser aperture tube 38 slidably received therein. The laser aperture tube 38 is of tubular construction and is adjustable in an axial direction so as to be telescopically received with the tubular member 79 of the piston rod 33 to provide an enclosure for the laser beam. The clamp block mounting screws 83 also pass through a pair of switch mounting angle brackets 86, 87, received alongside the clamp block 39. The switch mounting angle brackets 86, 87 support a pair of proximity switches 88, 89 at fore and aft positions which indicate the piston rod end-of-stroke positions by sensing the flange portion 80 of the tubular member 79. The outboard end of the laser aperture tube 38 has an external flange 42 welded therewith, and the flange 42 is provided with a plurality of bolt holes 43 for affixing the mirrored articulation of a laser light pipe system 21 (see Figure 1). Beneath the base frame plate 51, midspan of the structure, the end effector 20 of the articulatable wrist 19 of Figure 1 is shown mounted to a mounting plate 90 spaced apart from the plate 51 by blocks 91. A locating plug 92 is provided in the end effector 20 and in the base frame mounting plate 90, and a plurality of screws 93 are arranged in a bolt pattern around the locating plug 92. A plurality of coiled fluid supply hose 94 are connected to a junction block 95 at the rear, underneath the base frame plate 51. The junction block 95 is interdrilled and provided with hoses (not shown) extending to the fluid ports 67, 68 of the fluid cylinder 31 to provide motive power for the piston 32. The bottom plan view of Figure 5 more clearly shows the compact hose and junction block 95 and the end effector mounting screws holes 96. The rear member 50 of the base frame 26 is of generally fixed width, while the front member 49 is tapered from the vertical interface 57 to the upright vertical end plate 27. Triangular burned out portions 97 are provided through the front member 49 to lighten the structure.

The right side elevation shown in Figure 6

depicts that the laser aperture tube 38 is received in the clamp block 39 which is of generally solid construction having a saw slot 85 at its topmost portion with transverse screws 41 for clamping the tube 38 in a well-known manner. The bottom portion of the clamp block 39 has side-extending ears 39(a) and 39(b) for receiving mounting screws 83 through the rear support bracket 81. The proximity switches 88, 89 are shown mounted on the respective switch angle brackets 86, 87.

Figure 7 depicts the left side elevational view showing that the fluid cylinder 31 is provided with a base 32(a) for receiving mounting screws 98 and nuts 99 which secure the cylinder 31 to the cylinder support bracket 65. The cylinder support bracket 65 is in turn secured by screws 100 passing through it and the base frame plate 51 and held by nuts 101. The vertical plate 27 at the end of the assembly has a pair of screws 64 passing through, to secure to anvil 28 (see Figure 4).

The view shown in Figure 8 depicts an alternate embodiment of the laser spot welder 10(a), wherein the base frame 102 carries a laser aperture support block 103, and the laser aperture tube 104 extends rearwardly from the support block 103 to an articulation 105 formed at the end of a light pipe system 106. The laser aperture tube 104 has an anvil compression tube 107 telescopically mounted therein and slidable through bearings 108 carried in the base frame 102. The base frame 103 carries an anvil support bracket 109 which mounts an anvil 110 similar in manner to that shown and described in Figure 2. The anvil 110 is positioned against one side of a pair of workpieces 29, 30 to be welded together, and an anvil compression member 111 received on the anvil compression tube 107 is directed against the workpieces 29, 30 when a laser welding operation is to be performed. A fluid cylinder 112 is mounted to the top of the laser aperture support block 103 and has a single piston rod 113 extending from its forward end, parallel to the anvil compression tube 107. The piston rod 114 is coupled to the anvil compression tube 107 by a yoke 114 received on the threaded end of the piston rod 114 and welded to the compression tube 107. In such manner, therefore, the self-contained commercial cylinder 112 is used to provide bidirectional movement to the axial compression tube 107, and changeover of cylinders is easily accomplished. Further, it will be appreciated that since the load to be applied to the workpieces is in the nature of several pounds, no appreciable distortions or overturning moments will be realised by the bearings due to the offset cylinders mounting.

Another alternate embodiment is shown in Figure 9, wherein an industrial robot 14 and wrist 19 combination as described in connection with Figure 1, are used to support and move the laser spot welder 10 of Figure 1. However, in the assembly shown, a laser generator 115 is secured to the robot forearm 18 by a special

mounting bracket 116, and an articulatable light pipe system 117 is provided to direct the beam from the front end of the laser generator 115 to the aperture tube 38 of the laser spot welder 10.

While the laser spot welder unit described in connection with Figures 1 and 2 has been shown in conjunction with an industrial robot, it may also be appreciated by those skilled in the art, that the spot welder unit could be mounted to a dedicated manipulator, i.e., not having the programmable aspects of an industrial robot. Further, the laser spot welder could be mounted on a coordinate slide machine for performing repetitive welding operations in the same or parallel planes. It may also be appreciated that continuous welding may be effected through the embodiment shown and described in connection with Figure 3.

Claims

1. A laser welding apparatus for use with an industrial robot, comprising:

(a) a base frame (26, 102),

(b) a workpiece support (27, 28);

(c) a clamping device (33, 34, 107, 111) carried by the base frame (26, 102);

(d) means (31, 32, 33, 112) for moving the clamping device to clamp the workpiece against the workpiece support (27, 28); and

(e) means to direct a laser beam against a workpiece clamped between the support and the clamping device; characterised in that the workpiece support (27, 28) is carried by the base frame (26, 102) and the apparatus comprises means (90) for mounting said base frame (26, 102) on an end effector (19, 20) of the robot, and in that the clamping device comprises a linear piston (32, 112) which is provided with a through-extending axial passageway (35), means (21, 106, 117) being provided to direct a laser beam along said axis into said passageway (35) through the linear piston (32, 112) onto the workpiece.

2. Apparatus according to Claim 1, wherein the linear piston (32, 112) is movable in a fluid cylinder (31) mounted on the base frame (26, 102).

3. Apparatus according to one of Claims 1 and 2 comprising a tubular member (38, 104) fixed relative to the base frame (26, 102) and telescopically interfitted with said linear piston (32, 112).

4. Apparatus according to any one of the preceding claims comprising a laser focusing mechanism (36) carried in unison with said clamping device (33, 107) as said device moves relative to said base frame.

5. Apparatus according to any one of Claims 1 to 3 comprising a laser focusing mechanism which is fixed relative to the base frame.

6. Apparatus according to any one of the preceding Claims comprising a compression member (34, 111) provided by or adjacent to one end of the linear piston (32, 112).

7. Apparatus according to Claim 6 wherein said compression member comprises, in part, a roller (47) having its rotary axis substantially normal to the axis of movement of said linear piston.

8. Apparatus according to Claim 7 wherein said workpiece support comprises a first roller (46) having its rotary axis transverse to the axis of said passageway, the roller (47) having its rotary axis parallel to the axis of the first roller (46).

9. Apparatus according to Claim 6 wherein said compression member (34) comprises a ring-like portion (33).

10. Apparatus according to Claim 9 wherein said workpiece support comprises a ring-like member (28).

11. Apparatus according to any one of the preceding claims where said means to direct a laser beam along said axis into said passageway comprises a jointed light pipe conductor system (21, 106, 117) connecting a remote laser beam generator (115) to said apparatus.

12. Apparatus according to Claim 11 wherein said light pipe conductor system (21, 106, 117) is connected at its end remote from the laser beam generator to a hollow member (25, 38, 104) fixed in relation to said base frame coaxial with said passageway and telescopic with relation to said clamping device.

13. A laser welding machine comprising:

(i) an industrial robot having a wrist and wrist end effector (20) movable through multi-vector spatial orientations;

(ii) a workpiece support (27, 28); and

(iii) a laser welding apparatus comprising

(a) a base frame (26, 102);

(b) a clamping device (33, 34; 107, 111) and

(c) means (31, 32, 33, 112) for moving the clamping device to clamp a workpiece against the workpiece support; characterised in that the workpiece support (27, 28) is carried by the base frame (26, 102) and the base frame is mounted on the end effector (20) of the robot, and in that the clamping device comprises a linear piston (32, 112) with a through-extending axial passageway, the machine comprising an articulative light conductor system (21, 106, 117) adapted to be connected at one end to a remote laser beam generator and at the other end to the welding apparatus in a manner whereby a laser beam may be directed during a welding operation from the remote laser beam generator through the axial passageway of the clamping device onto said workpiece.

14. A machine according to Claim 13 wherein the articulative light conductor system is connected at said other end to a hollow member (25, 38, 104) fixed in relation to the base frame, said hollow member (25, 38, 107) being telescopically mounted relative to said clamping device (33, 35, 107), to move axially relative thereto during movement of the clamping device into engagement with said workpiece.

Patentansprüche

1. Laserschweißvorrichtung zur Verwendung mit einem Industrieroboter mit:

(a) einem Grundrahmen (26, 102);

(b) einem Werkstückhalter (27, 28);

(c) einer Klemmeinrichtung (33, 34, 107, 111), die von dem Grundrahmen (26, 102) gehalten wird;

(d) Mittel (31, 32, 33, 112) zum Bewegen der Klemmeinrichtung, um das Werkstück gegen den Werkstückhalter (27, 28) festzuklemmen; und

(e) Mittel, um einen Laserstrahl auf ein Werkstück zu richten, das zwischen dem Halter und der Klemmeinrichtung festgeklemmt ist;

dadurch gekennzeichnet, daß der Werkstückhalter (27, 28) von dem Grundrahmen (26, 102) gehalten wird und die Vorrichtung Mittel (90) zum Befestigen besagten Grundrahmens (26, 102) auf einem Wirkorgan (19, 20) des Roboters umfaßt, und daß die Klemmeinrichtung einen Linearkolben (32, 112) umfaßt, der mit einem sich hindurchstreckenden, axialen Durchgang (35) versehen ist, wobei Mittel (21, 106, 117) vorgesehen sind, um einen Laserstrahl entlang besagter Achse in besagten Durchgang (35) durch den Linearkolben (32, 112) auf das Werkstück zu richten.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß der Linearkolben (32, 112) in einem Fluidzylinder (31), der auf dem Grundrahmen (26, 102) befestigt ist, bewegbar ist.

3. Vorrichtung nach einem der Ansprüche 1 und 2, gekennzeichnet durch ein rohrförmiges Teil (38, 104), das relativ zum Grundrahmen (26, 102) fixiert und teleskopartig mit besagtem Linearkolben (32, 112) verbunden ist.

4. Vorrichtung nach einem der vorangehenden Ansprüche, gekennzeichnet durch einen Laserfokussierungsmechanismus (36), der in Zusammenklang mit besagter Klemmeinrichtung (33, 107) gehalten wird, wenn besagte Einrichtung sich relativ zu besagtem Grundrahmen bewegt.

5. Vorrichtung nach einem der Ansprüche 1 bis 3, gekennzeichnet durch einen Laserfokussierungsmechanismus, der relativ zum Grundrahmen fixiert ist.

6. Vorrichtung nach einem der vorangehenden Ansprüche, gekennzeichnet durch ein Druckteil (34, 111), das an oder neben einem Ende des Linearkolbens (32, 112) vorgesehen ist.

7. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß besagtes Druckteil zum Teil eine Druckrolle (47) umfaßt, deren Drehachse im wesentlichen senkrecht zur Bewegungsachse besagten Linearkolbens steht.

8. Vorrichtung nach Anspruch 7, dadurch gekennzeichnet, daß besagter Werkstückhalter eine erste Druckrolle (46) umfaßt, deren Drehachse quer zur Achse besagten Durchgangs liegt, wobei die Drehachse der Druckrolle (47) parallel zur Achse der ersten Druckrolle (46) liegt.

9. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß besagtes Druckteil (34) einen ringähnlichen Abschnitt (33) umfaßt.

10. Vorrichtung nach Anspruch 9, dadurch gekennzeichnet, daß besagter Werkstückhalter ein ringähnliches Teil (28) umfaßt.

11. Vorrichtung nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß besagte Mittel, um einen Laserstrahl entlang besagter Achse in besagten Durchgang zu richten, ein mit Gelenken versehenes Lichtleitersystem (21, 106, 117) umfaßt, das besagte Vorrichtung mit einem entfernten Laserstrahlgenerator (115) verbindet.

12. Vorrichtung nach Anspruch 11, dadurch gekennzeichnet, daß besagtes Lichtleitersystem (21, 106, 117) an seinem vom Laserstrahlgenerator entfernten Ende mit einem Hohlteil (25, 38, 104) verbunden ist, das fixiert in Bezug auf besagten Grundrahmen koaxial mit besagtem Durchgang und teleskopartig in Bezug auf besagte Klemmeinrichtung ist.

13. Laserschweißgerät mit:

(i) einem Industrieroboter mit einem Greifkopf und einem Greifkopf-Wirkorgan (20), bewegbar durch multivektorielle räumliche Orientierungen;

(ii) einem Werkstückhalter (27, 28); und

(iii) einer Laserschweißvorrichtung mit

(a) einem Grundrahmen (26, 102);

(b) einer Klemmeinrichtung (33, 34; 107, 111) und

(c) Mitteln (31, 32, 33, 112) zum Bewegen der Klemmeinrichtung, um ein Werkstück gegen den Werkstückhalter festzuklemmen;

dadurch gekennzeichnet, daß der Werkstückhalter (27, 28) vom Grundrahmen (26, 102) gehalten wird und der Grundrahmen auf dem Wirkorgan (20) des Roboters befestigt ist, und daß die Klemmeinrichtung einen Linearzylinder (32, 112) mit einem sich hindurcherstreckenden axialen Durchgang umfaßt, wobei das Gerät ein gelenkiges Lichtleitersystem (21, 106, 117) umfaßt, das so ausgelegt ist, daß es an einem Ende mit einem entfernten Laserstrahlgenerator und am anderen Ende derart mit der Schweißvorrichtung verbunden wird, daß ein Laserstrahl während eines Schweißvorgangs vom entfernten Laserstrahlgenerator durch den axialen Durchgang der Klemmeinrichtung auf besagtes Werkstück gerichtet werden kann.

14. Gerät nach Anspruch 13, dadurch gekennzeichnet, daß das gelenkige Lichtleitersystem an besagtem anderen Ende mit einem Hohlteil (25, 38, 104) verbunden ist, das in Bezug auf den Grundrahmen fixiert ist, wobei besagtes Hohlteil (25, 38, 107) teleskopartig relativ zu besagter Klemmeinrichtung (33, 35, 107) befestigt ist, um sich während der Bewegung der Klemmeinrichtung in Eingriff mit besagtem Werkstück relativ dazu axial zu bewegen.

Revendications

1. Appareil de soudage à laser utilisé avec un robot industriel, comprenant:

(a) un châssis de base (26, 102);

(b) un porte-pièce (27, 28);

(c) un dispositif de serrage (33, 34, 107, 111) supporté par le châssis de base (26, 102);

(d) des moyens (31, 32, 33, 112) pour déplacer le dispositif de serrage de façon qu'il serre la pièce contre le porte-pièce (27, 28); et

(e) des moyens pour diriger un faisceau laser contre une pièce serrée entre le support et le dispositif de serrage;

caractérisé en ce que le porte-pièce (27, 28) est supporté par le châssis de base (26, 102) et l'appareil comprend des moyens (90) pour monter ledit châssis de base (26, 102) sur un effecteur d'extrémité (19, 20) du robot, et en ce que le dispositif de serrage comprend un piston linéaire (32, 112) qui est muni d'un passage axial traversant (35), des moyens (21, 106, 117) étant prévus pour diriger un faisceau laser le long dudit axe dans ledit passage (35) à travers le piston linéaire (32, 112) et jusqu'à la pièce.

2. Appareil selon la revendication 1, dans lequel le piston linéaire (32, 112) est mobile dans un vérin hydraulique (31) monté sur le châssis de base (26, 102).

3. Appareil selon l'une des revendications 1 et 2, comprenant un organe tubulaire (38, 104) fixe par rapport au châssis de base (26, 102) et équipé télescopiquement dudit piston linéaire (32, 112).

4. Appareil selon l'une quelconque des revendications précédentes, comprenant un mécanisme de focalisation (36) supporté à l'unisson avec ledit dispositif de serrage (33, 107) quand ledit organe se déplace par rapport audit châssis de base.

5. Appareil selon l'une quelconque des revendications 1 à 3, comprenant un mécanisme de focalisation de laser qui est fixe par rapport au châssis de base.

6. Appareil selon l'une quelconque des revendications précédentes, comprenant un organe de compression (34, 111) constitué par ou adjacent à une extrémité du piston linéaire (32, 112).

7. Appareil selon la revendication 6, dans lequel ledit organe de compression comprend, en partie, un galet (47) dont l'axe de rotation est sensiblement perpendiculaire à l'axe du mouvement dudit piston linéaire.

8. Appareil selon la revendication 7, dans lequel ledit porte-pièce comprend un premier galet (46) dont l'axe de rotation est transversal à l'axe dudit passage, le galet (47) ayant son axe de rotation parallèle à l'axe du premier galet (46).

9. Appareil selon la revendication 6, dans lequel ledit organe de compression (34) comprend une portion de forme annulaire (46).

10. Appareil selon la revendication 9, dans lequel ledit porte-pièce comprend un organe de forme annulaire (33).

11. Appareil selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens pour diriger un faisceau laser le long dudit axe dans ledit passage comprend un système conducteur à tubes guides de lumière articulés (21, 106, 117) reliant un générateur de faisceau laser (115) situé à distance audit appareil.

12. Appareil selon la revendication 11, dans lequel ledit système conducteur à tubes guides de lumière (21, 106, 117) est relié à une extrémité éloignée du générateur de faisceau laser à un

organe creux (25, 38, 104) fixe par rapport audit châssis de base et coaxial audit passage et monté télescopiquement par rapport audit dispositif de serrage.

13. Soudeuse à laser comprenant:

(i) un robot industriel comportant un poignet et un effecteur d'extrémité (20) de poignet, mobile selon des orientations spatiales à vecteurs multiples;

(ii) un porte-pièce (27, 28); et

(iii) un appareil de soudage à laser comprenant:

(a) un châssis de base (26, 102);

(b) un dispositif de serrage (33, 34; 107, 111) et

(c) des moyens (31, 32, 33, 112) pour déplacer le dispositif de serrage de façon à serrer une pièce contre le porte-pièce;

caractérisé en ce que le porte-pièce (27, 28) est supporté par le châssis de base et le châssis de base (26, 102) est monté sur l'effecteur d'extrémité (20) du robot, et en ce que le dispositif de serrage comprend un piston linéaire (32, 112)

avec un passage axial traversant, la machine comprenant un système de guidage de lumière articulé (21, 106, 117) adapté à être relié à une extrémité à un générateur de faisceau laser situé à distance et à l'autre extrémité à l'appareil de soudage d'une manière telle qu'un faisceau laser puisse être dirigé pendant une opération de soudage depuis le générateur de faisceau laser situé à distance et par le passage axial du dispositif de serrage jusqu'à ladite pièce.

14. Machine selon la revendication 13, dans laquelle le système conducteur de lumière articulé est relié à ladite autre extrémité à un organe creux (25, 38, 107) fixe par rapport au châssis de base, ledit organe creux (25, 38, 107) étant monté télescopiquement par rapport audit dispositif de serrage (33, 35, 107), de façon à se déplacer axialement par rapport à ce dernier pendant le mouvement du dispositif de serrage l'amenant en engagement avec ladite pièce.

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FIG. 1

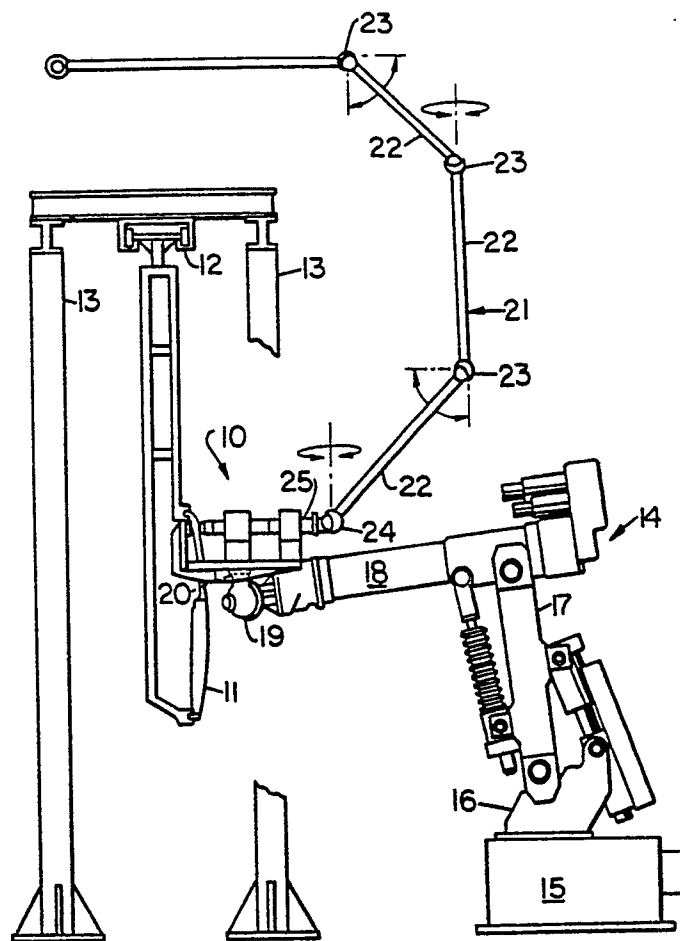


FIG. 3

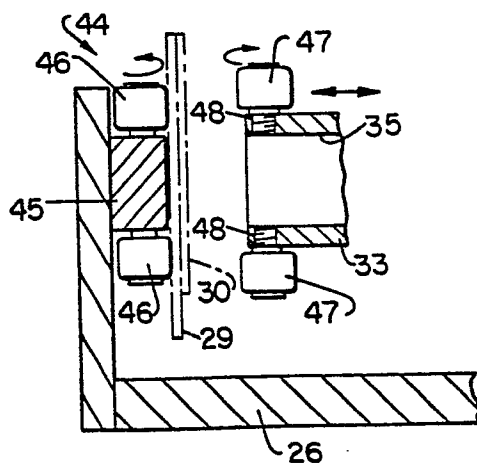
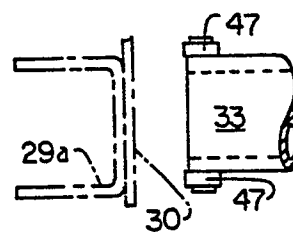


FIG. 3A



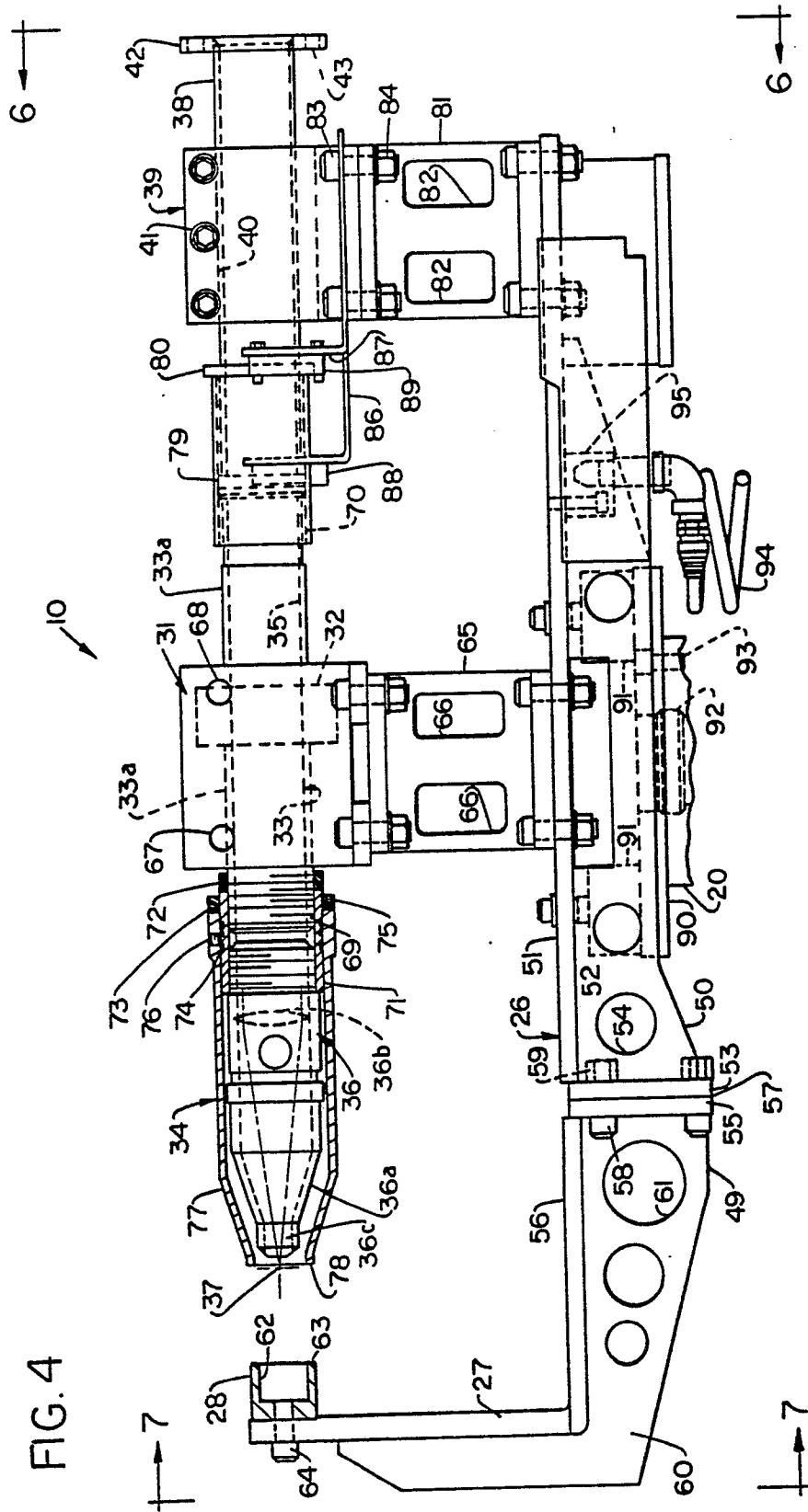


FIG.5

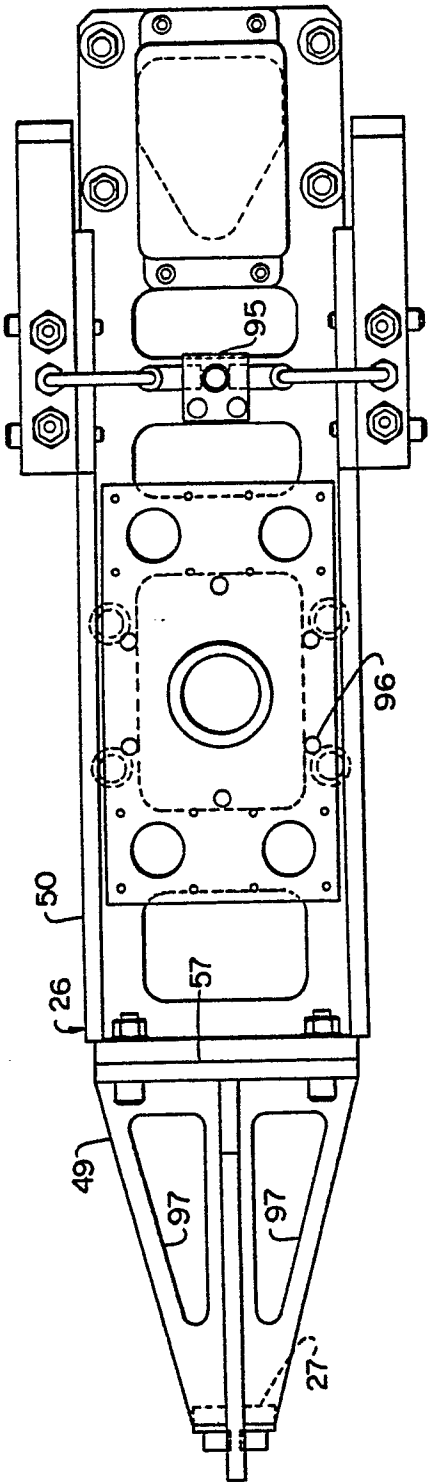


FIG. 6

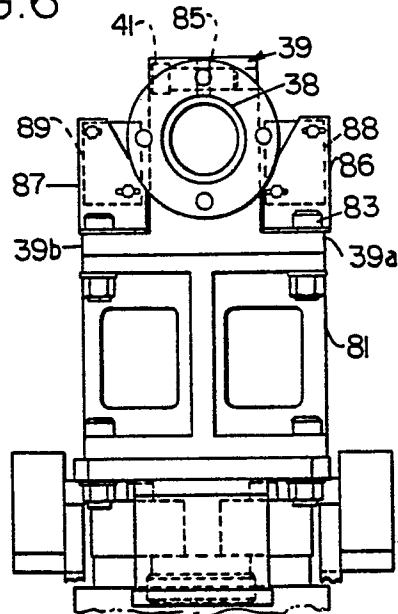


FIG. 7

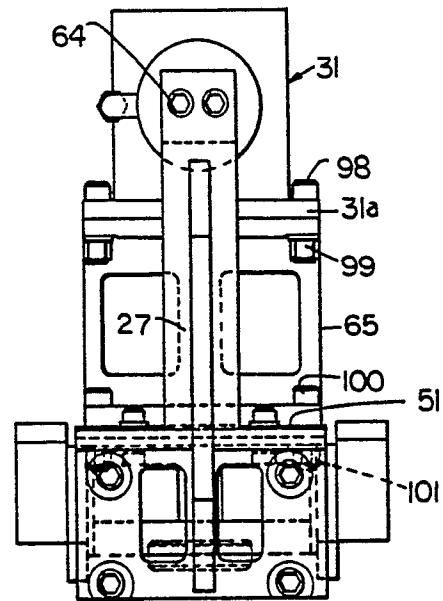


FIG. 8

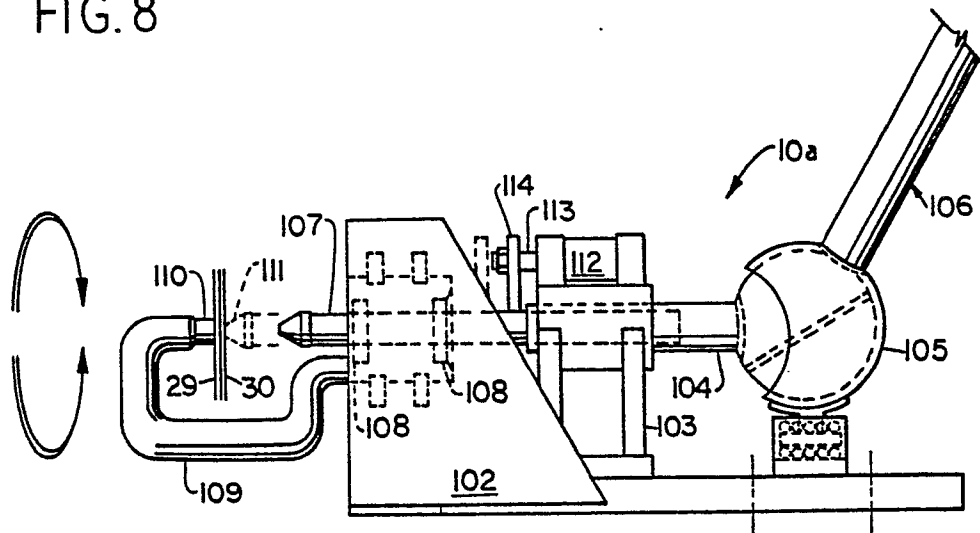


FIG.9

